

Adult entrainment and the Big Mama theory  
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I have taken a look at data related to two presentations at the recent CalFed Science Conference.

Bill Bennett suggested a “Big Mama” theory of smelt abundance. According to Bill, the larger delta smelt females are when they spawn, the more reproductively successful they are. Data suggest that not only do large females tend to have more eggs, but also, these eggs are more likely to survive. Bill also suggested that the number of large spawning females has declined in recent years. He said that large spawning females are the result of survival of early-hatched larvae the preceding year.

Bill suggested that the decline in abundance of large spawning females was in part caused by entrainment of early-hatched larvae. These larvae first hatch in late March or early April, a time when exports have typically been high in the period before the mid-April to mid-May export curtailment. Bill said that the magnitude of exports in this pre-VAMP period is not important because any export level would be sufficient to entrain the drifting larvae.

Pete Smith, using the same approach as for salmon and striped bass, estimated adult delta smelt entrainment from adult delta smelt salvage. Pete contrasted these estimates with ones I had made using the same general approach, but with different assumptions about the specifics. Pete stressed the uncertainty in all of these estimates, because little is known about louver efficiency and pre-louver mortality. He estimated that about 40% of adult delta smelt had been entrained in 2003.

I will first present information related to Pete’s estimates of percentage adult entrainment.

Using data from the Fall Midwater and Kodiak Spring Trawls, I estimated the distribution of adult delta smelt in recent years. This is shown on the table on page 6. This table shows the percentage of adult smelt in various parts of the Delta. The map on page 5 shows where the various areas are. The table on page 7 shows the approximate number of adult delta smelt in each area, assuming the Kodiak gear is approximately 100% efficient and adult smelt are only in the upper 12 feet of the water column. Without gear efficiencies for the FMWT, approximate numbers of adult smelt in December cannot be estimated.

In both tables, the column, “total ‘upstream’ and ‘downstream’” is the sum of the columns “Chippis Is. & downstream” and “Cache Creek & Sacramento River above 3 mile SL.” This column roughly shows the percentage or number of adult delta smelt that are so far from the export pumps that entrainment is highly unlikely.

I have circled relevant data for 2003, the year that Pete estimated adult entrainment of about 40%. As you can see, in December of 2002, 77% of the smelt were very far from the export pumps, and the rest were also far from the export pumps, in the lower Sacramento River. There was no Kodiak trawl in January of 2003. In February, 87% of the adults were very far from the pumps, 5% were in the lower Sacramento River, and 8% were closer to the export pumps. In January, average Delta outflow was about 51,000 cfs.

About 2,800 smelt were salvaged in December, 9,500 in January, 1,500 in February, and about 500 in March.

It seems unlikely that a significant percentage of adult delta smelt moved upstream in January and then back downstream in February, especially with Delta outflow at 51,000 cfs.

The fact that about 9,500 smelt were salvaged in a month when most delta smelt were far from the pumps leads to the conclusion that salvage, rather than being a significant percentage of the population, is actually a small percentage that can be significantly affected by the occurrence of relatively few smelt being close enough to the pumps to be entrained.

This is also supported by data from other years shown on the tables on pages 6 and 7. In other years, many more adult smelt were near the export pumps, yet salvage was lower.

Pete also presented correlations between Old and Middle River flows and adult salvage. I am having trouble with the mechanism underlying these correlations. If adult smelt were far from the pumps, these correlations would predict the same number of salvaged adults as if smelt were close to the pumps. If these correlations are not spurious, there must also be a correlation between the number of adult smelt near the pumps and Old and Middle River flows. Is there such a correlation?

For Bill's Big Mama theory, I first looked at the trend in the lengths of December adults. The graphs on page 8 show the length-frequency distributions for five-year groups of years. Note that there was a decline in December lengths, but it occurred around 1990. If anything, there seems to have been a slight increase in length in the POD period, 2000-2004.

The figures on page 9 confirm this. These figures show the mean and median lengths for each month of each year. There is a statistically significant downward trend, but it appears to be the result of a step change around 1989. Again, if anything, the mean and median lengths seem to be slightly increasing during the POD years, although I would not make much of that except to rule out decreasing adult length as a cause of the recent decline in delta smelt abundance.

The figures on page 10 show the relationship between four indices of abundance and the number of larger delta smelt ( $>59\text{mm}$ ) the previous December. I chose 59 mm as the cutoff length because there were so few delta smelt of greater length.

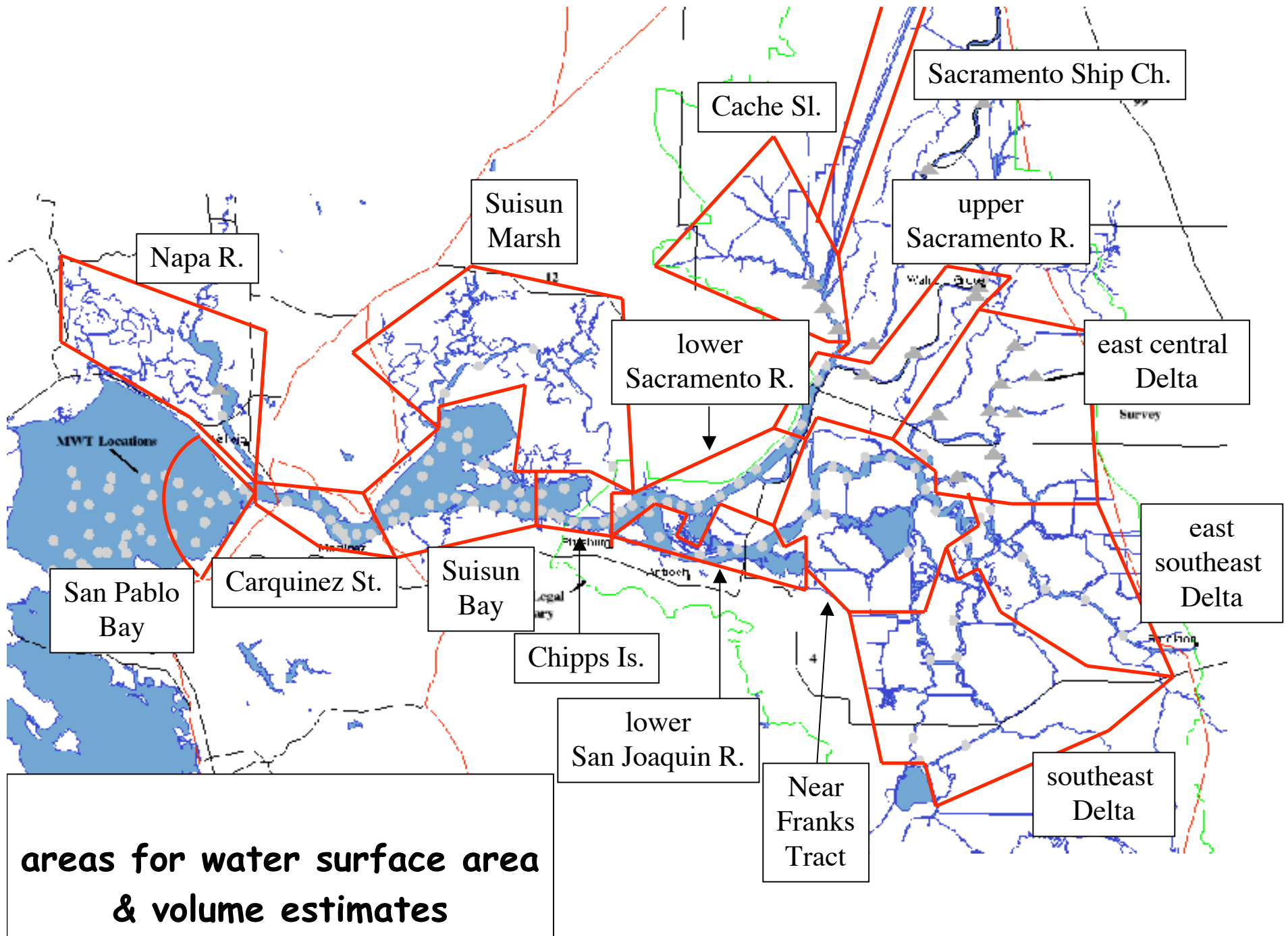
As you can see, there are no relationships between the number of large delta smelt in December and subsequent abundance.

I also estimated egg production using Bill's egg/female vs. length curve (from his presentation and from page 9 of his delta smelt paper for the online journal SF Estuary & Watershed). I found the average percentage increase in adult length from December to February when spawning begins. It was about 10%. I scaled up the December lengths by this factor, then used Bill's egg/female curve to estimate the relative number of eggs produced. The graphs on page 11 show the relationship between egg production and subsequent abundance indices. There are no relationships.

Finally, because larger females are thought to not only produce more, but higher quality, eggs, I increased the slope to Bill's eggs/female curve and shown on the inset graphs on page 12. This would give even greater weight to larger females. Using this modified eggs/female curve, I estimated what I termed "enhanced" egg production. This estimate also shows no relationship with subsequent abundance indices.

I do not think this means that Bill's Big Mama Theory is incorrect. It seems plausible. However, to the extent that the data and the analyses I did so far are valid, there is not evidence that the Big Mama theory is important, possibly because there has not been a decline in adult smelt length for the last 15 years or so.

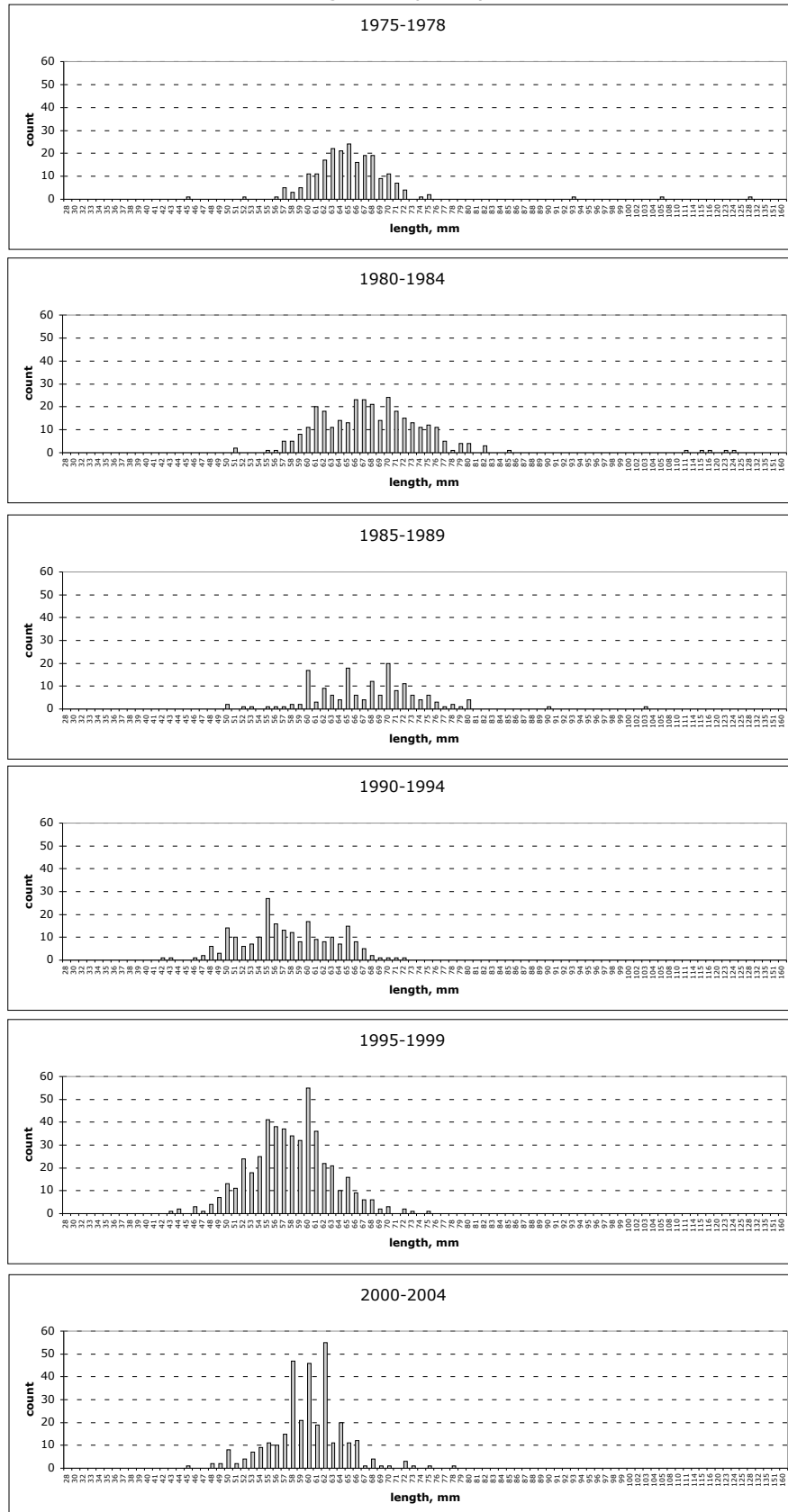
More work should be done on all of these hypotheses. This is just a start. Certainly, before any large, expensive "experiments" are done this Winter and Spring, we should thoroughly analyze the existing data to see if any experiment is likely to produce meaningful results.



adult delta smelt distribution and related data															
month	area	adult delta smelt distribution							related data				Pete Smith estimates of % adult entrainment		comments
		Chippis Is. & downstream	Cache Creek & Sacramento River above 3mle Sl.	total "upstream" and "downstream"	lower Sacramento River	lower San Joaquin River	near Franks Tract	east of Franks Tract	Delta outflow	adult salvage	total SWP & CVP exports cfs	approx. adult population	Pete Smith % adult entrainment	ratio: entrained smelt/adult salvage	
Dec	2002	0%	19%	19%	53%	18%	11%	0%	24,733	1,129	9,796		15%	27	
Jan		62%	1%	63%	2%	15%	17%	3%	38,734	5,231	10,611	906,887			
Feb		66%	0%	66%	5%	13%	16%	0%	12,029	280	8,581	1,235,298			
Mar		39%	25%	65%	27%	1%	4%	3%	16,964	225	8,078	643,465			
Apr									11,892	12	4,258				
May									13,483	0	1,534				
Dec	2003	73%	4%	77%	23%	0%	0%	0%	26,885	2,800	7,498		40%	17	40% entrainment estimate is not consistent with distribution of smelt. Missing data in January when salvage was high, but Delta outflow was relatively high, so it is unlikely that adult smelt shifted their distribution closer to the pumps from December to January, which is the only way 40% could have been entrained
Jan									51,440	9,549	10,033				
Feb		37%	50%	87%	5%	2%	4%	2%	29,622	1,491	10,658	611,367			
Mar		45%	32%	77%	19%	0%	2%	2%	15,761	483	10,571	477,103			
Apr		3%	55%	58%	16%	1%	25%	0%	22,029	36	4,478	336,064			
May		53%	25%	78%	11%	9%	0%	2%	41,877	0	2,448	64,946			
Dec	2004	10%	2%	12%	88%	0%	0%	0%	23,820	126	8,428		23%	21	
Jan		57%	0%	57%	0%	14%	23%	5%	32,104	4,594	11,187	1,160,979			
Feb		28%	0%	28%	26%	8%	36%	2%	68,091	1,161	10,376	744,759			
Mar		42%	0%	42%	24%	2%	29%	4%	56,256	2,267	11,029	479,835			
Apr		2%	25%	27%	37%	7%	30%	0%	21,948	0	4,098	321,996			
May		0%	84%	84%	4%	7%	6%	0%	12,354	0	1,714	227,663			
Dec	2005	24%	24%	48%	52%	0%	0%	0%	12,449	0	8,019		12%	22	The estimate of 12% entrainment is not consistent with the low percentage of smelt in or upstream of the lower San Joaquin river.
Jan		52%	13%	65%	27%	0%	7%	1%	33,589	1,647	12,018	704,654			
Feb		55%	33%	88%	11%	1%	0%	0%	24,922	389	8,827	370,234			
Mar		18%	69%	87%	13%	0%	0%	0%	38,546	0	6,992	170,749			
Apr		10%	76%	86%	14%	0%	0%	0%	29,876	0	5,989	132,343			
May									50,929	0	2,986				

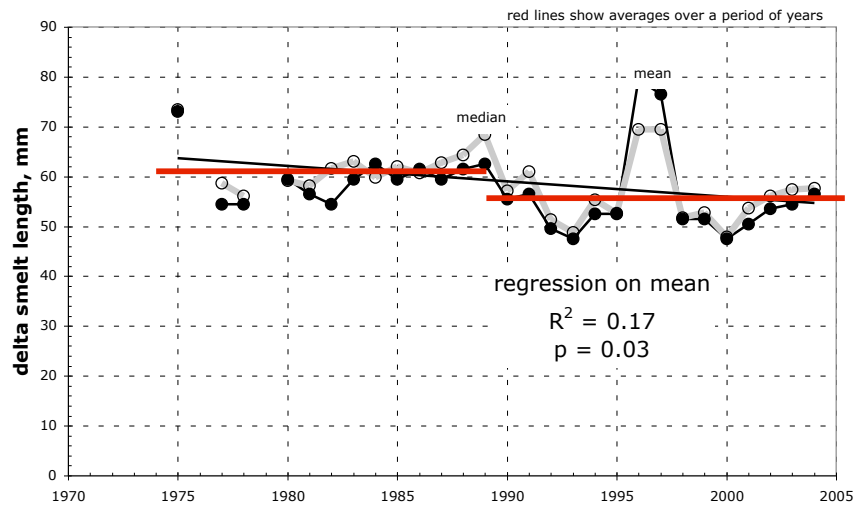
adult delta smelt approximate population and related data															
month	area	adult delta smelt approx. population, 1,000s							related data				Pete Smith estimates of % adult entrainment		comments
		Chippis Is. & downstream	Cache Creek & Sacramento River above 3mile Sl.	total "upstream" and "downstream"	lower Sacramento River	lower San Joaquin River	near Franks Tract	east of Franks Tract	Delta outflow	adult salvage	total SWP & CVP exports cfs	approx. adult population	Pete Smith % adult entrainment	ratio: entrained smelt/adult salvage	
Dec	2002								24,733	1,129	9,796		15%	27	The number of smelt near and east of Franks Tract was much higher in 2002 than in 2003, exports were higher, and outflow was lower, yet salvage was less than half that in 2003. The estimate of % adult entrainment was only about 1/3(+) that in 2003.
Jan		559	12	571	19	134	152	30	38,734	5,231	10,611	906,887			
Feb		809	5	814	64	160	198	0	12,029	280	8,581	1,235,298			
Mar		253	164	417	174	8	24	20	16,964	225	8,078	643,465			
Apr									11,892	12	4,258				
May									13,483	0	1,534				
Dec	2003								28,885	2,800	7,498		40%	17	
Jan									51,440	9,549	10,033				
Feb		228	303	531	29	14	27	11	29,622	1,491	10,658	611,367			
Mar		215	150	365	92	0	10	11	15,761	483	10,571	477,103			
Apr		10	184	194	55	3	83	0	22,029	36	4,478	336,064			
May		34	16	51	7	6	0	1	41,877	0	2,448	64,946			
Dec	2004								23,820	126	8,428		23%	21	Adult salvage was more than in 2002, consistent with the larger number of smelt near & east of Franks Tract. However, it was much less than in 2003 even though many times as many smelt were near or east of Franks Tract. Exports were about the same as in 2003 and higher than in 2002.
Jan		664	2	666	4	165	268	58	32,104	4,594	11,187	1,160,979			
Feb		208	1	210	197	56	266	17	68,091	1,161	10,376	744,759			
Mar		199	0	199	114	10	139	18	56,256	2,267	11,029	479,835			
Apr		7	80	87	119	21	96	0	21,948	0	4,098	321,996			
May		0	190	190	10	15	13	0	12,354	0	1,714	227,663			
Dec	2005								12,449	0	8,019		12%	22	
Jan		366	89	455	192	0	52	5	33,589	1,647	12,018	704,654			
Feb		203	123	326	41	3	0	0	24,922	389	8,827	370,234			
Mar		32	117	149	22	0	0	0	38,546	0	6,992	170,749			
Apr		13	101	114	18	0	0	0	29,876	0	5,989	132,343			
May									50,929	0	2,986				

# delta smelt December length-frequency distributions from FMWT

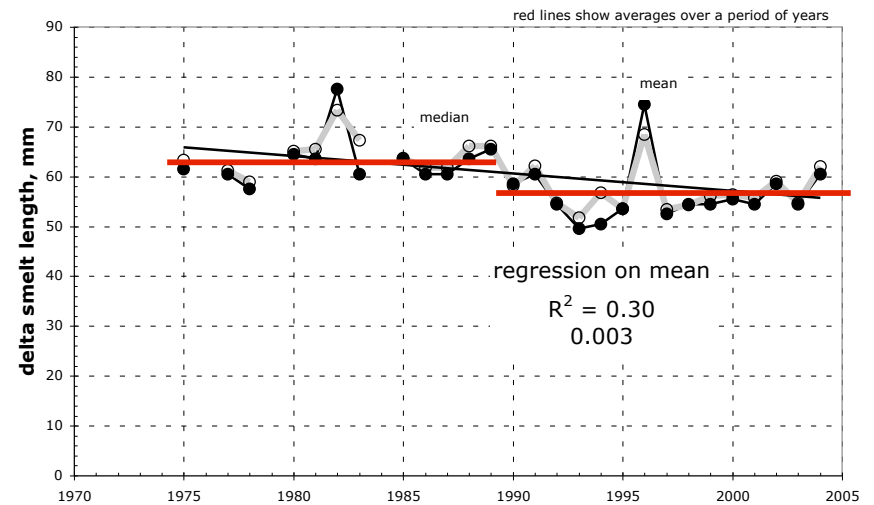




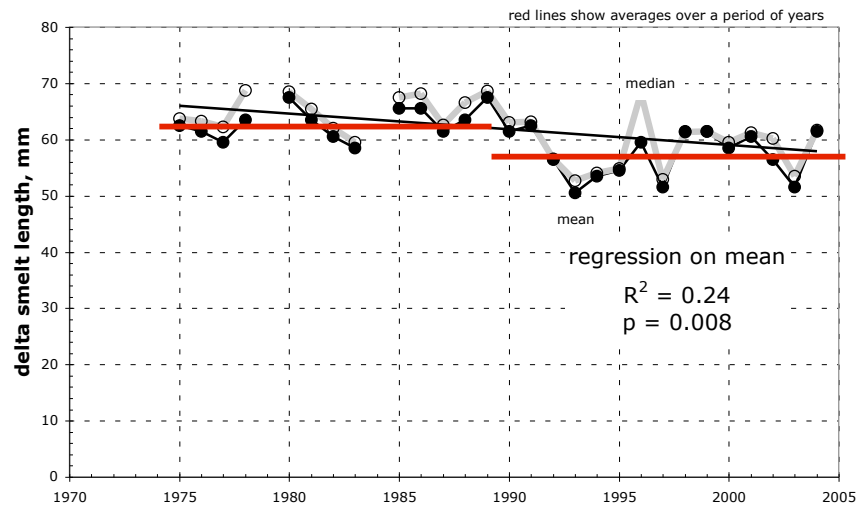
**Sept delta smelt length**



**Oct delta smelt length**



**Nov delta smelt length**



**Dec delta smelt length**

